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7. AUTHOR(S)

Raymond A. Forsyth and Joseph P. Egan, Jr.

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TRANSPORTATION LABORATORY
RESEARCH REPORT

USE OF WASTE MATERIALS IN EMBANKMENT CONSTRUCTION

76-06

Presented at the 55th Annual Meeting
of the Transportation Research Board
January 1976

Caltrans
CALIFORNIA DEPARTMENT OF TRANSPORTATION

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION AND RESEARCH
TRANSPORTATION LABORATORY

USE OF WASTE MATERIALS IN EMBANKMENT CONSTRUCTION

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Prepared for Presentation at the Annual Meeting
of the Transportation Research Board,
Washington, D.C.

January, 1976

Raymond A. Forsyth
Joseph P. Egan, Jr.

ABSTRACT

The impact of environmental constraints and economic considerations compel the engineer to seek new and novel techniques for utilizing waste materials in embankment construction. This paper describes the use and design criteria for incorporating (1) wood waste, (2) sanitary landfill waste, and (3) nonbiodegradable waste (discarded tires) in California Highway embankments. Construction guidelines and theoretical considerations are presented. Two case histories are described, in addition to plans for a test embankment which will be stabilized by tire sidewall mats.

INTRODUCTION

California practice, in common with that of most other road building organizations has hitherto placed severe restriction on the incorporation of "unsuitable materials" on highway embankments. Clearing and grubbing was an important and rigidly adhered to first step in the highway construction process. The burial of logs and stumps was prohibited and, indeed, in some cases, knots and twigs were picked out of embankments as part of the construction process. When necessary to cross sanitary landfills, the waste was stripped to original ground and disposed of prior to construction of the embankment as a matter of course.

In recent years, environmental restrictions, economics and concern for visual impact have necessitated construction of highways over marginal to extremely difficult terrain. To compound the problem, the options with respect to development of borrow and waste disposal sites have been severely restricted. Thus it has become necessary to reevaluate past highway practice with respect to waste or unsuitable materials.

This paper discusses the use of three types of waste materials incorporated into embankments constructed along California highways. These include wood waste, sanitary landfill waste, and nonbiodegradable waste (discarded tires).

The burial of wood waste in California embankments has been used on several projects in recent years. A recent example is Route 46, between Paso Robles and Cambria, which was completed in 1974.

In recent years, several case histories (1, 2) have appeared in the literature concerning the crossing of sanitary landfills with highway embankments which described the construction technique and the results of measures aimed at minimizing post construction settlements.

On Route 73 in Orange County, the California Department of Transportation is nearing completion of a project in which sanitary landfill waste is incorporated into embankment construction. This project will subsequently be described in detail.

In addition, a test embankment yet to be constructed will be described in which it is believed a systematic incorporation of tire waste will actually serve to beneficiate the fill so as to permit steeper than normal side slopes and increase its resistance to seismic loading.

A. WOOD WASTE

General Design Criteria

Beginning in the early 1970's the California Department of Transportation had acquired a limited amount of experience in the burial of wood waste in embankments resulting from clearing operations. The criteria developed with this method of disposal are as follows:

1. Burial should be in an environment which is not subject to alternating wet and dry cycles.

2. Wood waste should not be permitted any closer than 6.1 meters (20 feet) to profile grade. A minimum distance of 3.05 meters (10 feet) from the edge of fill for placement of wood waste should be maintained to minimize the ingress of oxygen which would hasten the process of deterioration.

3. The spacing of stumps and logs should be such that construction equipment will have sufficient room to work in and around for adequate compaction.

4. Layers of slash and brush should be placed in 45.7 centimeter (18-inch) lifts, sandwiched between 0.92 meter (3-foot) minimum lifts of compacted embankment soil.

CASE HISTORY (Route 46, between Paso Robles and Cambria)

This was one of the first projects in which the above criteria were utilized. The facility was on totally new alignment over very steep and heavily wooded terrain. Construction began in June of 1972 and was completed in 1974. Layers of stumps and tree trunks were placed at 3.05 meter (10-foot) intervals between soil layers in a total of six embankments ranging from 28 to 50 meters (93 to 165 feet) in height. A cross-section of the disposal scheme is shown on Figure 1. The placement of logs and stumps was closely supervised and documented.

The contractor was required to trim branches from logs to within 0.61 meter (2 feet) to minimize interference with construction equipment. After trimming, the logs were placed in rows along the embankment parallel to centerline. These rows were kept at least 6.1 meters (20 feet) from the slope line with a 6.1 meters (20-foot) interval between individual rows to provide adequate working room for equipment. After formation of the rows, embankment was placed around them, watered and compacted.

Embankment placement continued until a minimum of 3.05 meters (10 feet) of compacted embankment lay between the rows of logs and stumps, at which time another layer was placed, and the compaction procedure repeated.

The slash from trimming operations and brush were disposed of by excavating deep trenches outside of the embankment toe. In some cases, disposal was accomplished by construction of a disposal strut fill outside of the design slope limit.

Embankments constructed in this manner after three winters showed no sign of distress or localized settlement. Settlement that has occurred has been found to be relatively uniform and is attributable to embankment settlement and foundation consolidation.

B. SANITARY LANDFILL WASTE

Design Criteria

No general design criteria are described here as the contract specifications for the case history described below are included in the discussion.

CASE HISTORY (07-ORA-73, P.M. 2.7/4.0)

This project consists primarily of an interchange in Newport Beach, California, near the Irvine Campus of the University of California (see Figure 2). One segment of the interchange provides ramp access to MacArthur Boulevard which was relocated to accommodate future full freeway alignment.

The results of a foundation investigation revealed that foundation soils were generally soft and compressible, necessitating 2:1 side slopes, stabilizing berms, waiting periods and controlled rates of loading for embankment construction.

The general pattern of foundation soils consists of alternating strata of compressible clay and fine to coarse sands which appear to be free draining. Figure 3 shows the boring locations and the log of the borings for a portion of the realigned MacArthur Boulevard, including a portion of the sanitary landfill.

In addition, a portion of a sanitary landfill containing 152,920 cubic meters (200,000 cubic yards) of refuse occupied a section of the line along which the realigned MacArthur Boulevard and University Drive would be constructed. Construction of this landfill began in 1954 and was completed with 0.6 meter (2 feet) of earth cover in 1961.

As the design of the interchange was nearing completion, it become apparent that removal of this huge quantity of waste would involve a tremendous expenditure. Construction of embankments over the landfill would subject the roadway to intolerable long-term settlement compounding the problem already present due to the nature of the subgrade soils.

Inquiries by designers with respect to disposal of the waste revealed that the only available option was placement in another sanitary landfill. Since the project was deficient in embankment, the 152,920 cubic meters (200,000 cubic yards) would have to be replaced by material obtained from outside the project limits at an estimated cost of $3.92 per cubic meter ($3.00 per cubic yard) delivered to the site. Thus, the potential net savings available by utilizing the waste in embankment construction was estimated at $900,000.00. This enormous potential savings prompted further study of the possibility of utilizing the waste in the embankments.

There was little information to draw upon with the exception of recent limited experience in burial of wood waste in embankments described previously. The specifications ultimately developed by District Design, Construction and Transportation Laboratory personnel for this purpose are shown below:

"Those areas shown on the plans as '<u>Refuse Removal Area</u>' are areas of unsuitable material. The Contractor shall excavate the refuse cover and refuse material and construct embankments within the excavated refuse area with material obtained from excavation within the project limits (except excavated refuse material) or borrow.

"At the option of the Contractor, excavated refuse material may be used in embankment construction in the areas shown on the plans as '<u>Refuse Embankment Areas</u>'.

"In addition to the requirements in Section 19-5, 'Compaction', and Section 19-6, 'Embankment Construction', of the Standard Specifications, the placement of excavated refuse material in embankments shall conform to the following:

1. Excavated refuse material shall be thoroughly mixed with suitable embankment material at a rate not to exceed 50% of the mixture.

2. Each layer of the refuse material mixture shall be covered with at least 2 layers of suitable embankment material.

3. No layer of the refuse material mixture shall be placed with 1.2 m (4 feet) of finished grade.

4. Rock, portland cement concrete, asphalt concrete, ferrous and nonferrous metals shall not exceed one foot in the vertical dimension when placed in embankments.

5. All other material including biodegradable material shall not exceed 15.24 cm (one-half foot) in greatest dimension.

"Suitable embankment material referred to herein shall be considered as material excavated from within the limits of this project (except refuse material) or borrow.

"During the operations of excavating and depositing refuse material, the Contractor shall take precautions to prevent offensive odors within the surrounding area. Such precautions may consist of the use of earth cover or the application of commercial odor masking compound as directed by the Engineer. Precautions to prevent offensive odors will be paid for as extra work as provided in Section 4-1.03 of the Standard Specifications.

"Excavation of the refuse material will be paid for as roadway excavation (Type A)." A typical embankment cross-section is shown on Figure 4.

The heterogeneous nature of the waste precluded compaction control by conventional means. However, it was reasoned that placement of waste in relatively thin lifts sandwiched between layers of soil would minimize the risk of low densification, since in order to achieve specification compaction requirement in the soils layers, a relatively firm working table would be necessary.

Refuse embankment construction requirements of the special provisions to the contract included the following:

1. Strip surface materials at refuse embankment sites to Elevation 4.0 feet.

2. Construct embankments to finished embankment height subject to the following rates of loading:

   a. First 2.75 meters (9 feet) of embankment to be placed at a rate of 0.41 meter (1.33 feet) per week followed by a 60-day waiting period.

   b. Second stage: Construct the embankments to Elevation 6.71 meters (22.0 feet) at a rate not to exceed 0.41 meter (1.33 feet) in any seven consecutive calendar days followed by a 60-day waiting period.

   c. Third stage: From 5.49 meters (18 feet) of embankment height (Elevation 22.0 feet) to finished grade elevation construction should be at a uniform rate not to exceed 0.91 m (3-foot) increments in height in any seven calendar days.

For the purpose of construction control heave stakes, piezometers, settlement platforms, benchmarks and inclinometers were installed. Additional benchmarks were installed at the top of the fills above the settlement platforms at original ground to monitor compression occurring within the fill itself. As of this date (December 1, 1975) no significant compression has been detected with the fill.

Excavation of the landfill exposed a composition of wood, stumps, paper, fibrous wastes, cans, bedsprings, pipe, wire, glass containers, plastics, tires, bricks, and concrete debris. Organic materials encountered were generally in a good state of preservation. Newspapers dated in the late 1950's were clear and readable. As had been anticipated based upon the exploration of the fill in late 1970, groundwater was encountered from 4.6 to 6.1 meters (15 to 20 feet) below ground surface. This water was ponded and later pumped into tank trucks for use in the compaction operation. No discharge of groundwater was permitted into San Diego Creek. Leacheate was not considered to be a problem and no program to monitor leachates from the embankment was initiated because the refuse was to be incorporated into embankments several feet above the water table sandwiched between layers of relatively impermeable soil. The refuse was excavated from the locations designated on Figure 2 and hauled to the embankment areas with rear-dump trailer and tractor trucks. Actual excavation of the refuse was attempted with various pieces of equipment. Use of a front-end loader was unsuccessful since large masses of saturated materials such as rags and paper were encountered.

The bucket working in scoop fashion was not easily filled. The device that ultimately proved most successful for refuse excavation and loading was a hydraulic backhoe. This had several advantages, including a digging action from the top downward into the saturated refuse which penetrated the rags and paper on the initial thrust and filled the bucket. Wet soft areas were worked by reaching out and down without the machine carriage entering and bogging down. The backhoe capacity was found to be approximately 229 cubic meters (300 cubic yards) of refuse per hour. After the refuse was hauled to the embankment location and dumped, bulldozers spread the material in lifts approximately 15.2 centimeters (1/2 foot) thick as shown in Figures 5 and 6. At this point, unsuitable pieces, including tires were picked out, stockpiled, and eventually hauled away for disposal at a public dump. One such stockpile is shown on Figure 7.

Embankment soils for blending with the refuse were hauled to the site in twin-bottom dump trailers. The soil was spread over the in-place refuse with rubber-tired dozers and motor grader as shown by Figure 8. Mixing was accomplished with either a sheepsfoot roller pulled by dozers or a self-propelled sheepsfoot compactor as shown by Figure 5. The compactor spikes penetrated the soil and rubbish; pulling, ripping, and splitting the rubbish as it was mixed with the soil and compacted. The principle problem was the tendency for the equipment to become plugged with refuse. The sandy soil which was used for the embankment proved to be an asset for the blending operation due to its low cohesion. A similar attempt to mix cohesive or clayey soils with the refuse would have been extremely difficult, if not impossible.

The moisture content of the refuse buried was from dry to saturated. Saturated refuse was spread and allowed to air dry prior to blending with the soil. Specifications were included for odor control of the refuse during handling operations. A commercial deodorant, available for use in the event obnoxious odors were encountered on this project, was not necessary.

Embankment compaction control of density and moisture contents of soil lifts that sandwiched the blended refuse lifts was maintained with nuclear gages. A relative compaction requirement of 90% of California Test Method No. 216 was specified and achieved for the soil portion of the embankment.

Compaction control of the blended refuse layers was achieved by visual inspection. Inspectors observed the blending and compaction of the refuse layers and directed the modification of the operation where inadequate compaction or mixing were observed. Exposed layers of the blended refuse were seen as a result of an excavation for a drainage culvert as shown on Figure 9. The blended refuse layers appear across the center of Figure 9, sandwiched between two soil layers. A closeup view of the blended layers is shown on Figure 10. No cavities were observed in the exposed layer. A closeup view of the blended layers is shown on Figure 10. No cavities were observed in the exposed layer. The soil and refuse were moist, thoroughly mixed and could be separated only by using a handpick. The layer appeared to be well compacted.

The sandy soil used for embankment eased the problem of mixing considerably. It is very doubtful that such an operation would be successful with cohesive materials.

C. NONBIODEGRADABLE WASTE

General Design Criteria

Engineers have long been aware of the stabilizing effects of inclusions of various materials in earthworks. The first disciplined, and by far the most extensive and successful application of soil reinforcement, was developed by the

French Engineer Henri Vidal (3) in the late 1950's. Vidal's system known as "Reinforced Earth" consists of placing steel reinforcing strips at predetermined intervals within the fill mass for the purpose of providing tensile and/or cohesive strength in a relatively cohesionless material. For a soil to be satisfactory for reinforced earth construction Vidal suggests that it be granular, having an angle of internal friction of at least 25° in order to develop adequate frictional resistance between the soil and the reinforcing material.

Various materials other than steel are also beneficial in providing mechanical stabilization to embankment construction. The stabilizing effect of materials with relatively high tensile strength in soil has been observed since ancient times. Increase shear strength with certain types of nonbiodegradable materials was noted during the Laboratory study of the California Department of Transportation (4).

One of the most perplexing problems in the disposal of solid waste involves that of discarded automobile tires. It has been reported that approximately 200 million tires are discarded each year in the United States. This problem was of sufficient magnitude in California to prompt House Resolution #37 in the 1973 California Legislative Session, which charged the California

Department of Transportation to study the problem of abandoned ties and develop possible solution for disposal and recycling of used tires.

The major objection to burial of tire carcasses in soil stems from the fact that tires have a tendency to work to the surface when placed in sanitary landfills. Equipment is now available commercially to cut automobile tires into three portions, separating the thread from the sidewalls. these tire sidewalls or half-tire units are placed in strips or ties and layed on mats at given intervals within the embankment. This type of application utilizes the reinforced earth principle. It is speculated that additional embankment soil strength could be provided by the tires placed in this manner. The embankments would also serve as disposal sites for this waste product.

To study this possibility further, an analysis was conducted at the Transportation Laboratory to determine the theoretical effects of tire reinforcement on earthquake resistance of embankments. This analysis assumed tire placement in mats extending for widths of eight tenths of the embankment height at vertical intervals of 1.22 meters (four feet). It was accomplished with Quad-4 finite element program developed at the University of California at Berkeley. The finite element mesh (Figures 11 and 12) consisted of elements representing the reinforcing mat and boundary soil.

The embankment was assumed to have a relative density of 90% and a density of 2.083 gms/cu cm (130 pcf). Shear modulus (G) was assumed to vary with overburden height as shown by the following equation (4):

(1) $G = K_2 \; (\sigma_o^1)^{1/2}$

Where G = shear modulus in ksf

K_2 = a function of relative density (D_r)

The foundation soil was also assumed to be sandy with a relative density of 75% and a density of 2.083 gms/cu cm (130 pcf). From Equation 1, the K_2 of the 1.5 meters (5 feet) of foundation soil is 61. For the composite material, a constant shear modulus of G = 133 ksf was utilized based upon the results of tests on rubber tire specimens. A constant damping factor of 25% was also used. The embankment was assumed to be 7.02 meters (23 feet) in height with 1-1/2:1 side slopes. The earthquake selected was the Cal Tech C-1 with a maximum acceleration of 0.3 g, a period of 0.35 sec., and a duration of 12 sec. applied at the base of 1.5 meters (5 feet) of foundation material. This would correspond to a Richter magnitude shake of 7 at a distance of 11.3 kilometers (15 miles) from the fault. The results in terms of change or reduction in the dynamic shear stress and strain resulting from reinforcement are shown on Figures 11 and 12. As shown on Figure 11, under these conditions dynamic shear strength would be reduced in the embankment soil by from 20% to 62%, averaging about 33%. The greatest reduction occurs in the interior which would indicate that failure, if it did occur, would probably be of a surficial nature. The same trend is noted on Figure 12 with respect to shear stress with an average reduction in the embankment soil of about 33%.

These values would, of course, vary with side slope, type of soil, earthquake intensity and duration, and fill height. The results of this analysis and the earlier Laboratory study of the stabilizing effect of waste led to a decision to construct a prototype test embankment utilizing tire sidewall mats for reinforcement. F.H.W.A. approval for the instrumentation and analysis portions as an H.P.R. project was received August 8, 1973.

<u>ROAD 04-CC, 4.4/4.5</u>

This site was chosen for experimentation after reviewing several potential projects. It is located in the vicinity of the

Franklin Canyon Fault which is considered active but has no historical evidence of recent movement.

The embankment will have an ultimate height of 18.3 meters (60 feet). A partial fill to within about 4.58 meters (15 feet) of finished grade exists at the present time which was constructed at the westerly end of a previous contract.

A tentative design consists of placing automobile tire sidewalls or half-tire units in transverse strips at longitudinal intervals of 1.5 meters (5 feet), with approximately 0.5 meter (1-1/2 feet) of vertical embankment (3 lifts of soil) cover between tire strips. A schematic of the installation is shown by Figure 13.

Instrumentation will be included in construction to monitor performance over a one- to two-year period prior to incorporation of the embankment in final construction. Instrumentation will include settlement platforms, horizontal movement devices, instrumentation on tires, vertical and horizontal reference points, vertical soil pressure cells and slope indicators. Figure 14 shows a typical section of the proposed embankment construction. Figure 15 shows the proposed instrumentation for a typical control section. It is proposed that embankment side slopes vary from 2:1 to 3/4:1 and instrumentation be placed at three levels in four different sections. Instrumentation will be common to all sections with the exception of the control section which will be constructed without vertical pressure cells.

SUMMARY AND CONCLUSIONS

Environmental constraints and economic considerations have in recent years necessitated a reevaluation of past highway practice with respect to inclusion of waste materials in embankments. Buring restrictions have stimulated the incorporation of wood waste resulting from clearing, not only under flattened embankment slopes, but also within the main embankment. Logs and stumps were spread in embankments measuring in height from 28 to 50 meters (93 to 165 feet) on Route 46 from Cambria to Paso Robles in 1972-74 without serious difficulty or apparent effect on the performance of the facility.

It is believed that wood waste can be successfully incorporated into embankment construction provided:

1. They are not subject to alternate cycles of wetting and drying.

2. A minimum distance of 6.1 meters (20 feet) from profile grade and 3 meters (10 feet) from the embankment edge is maintained.

3. The space of stumps and logs is such to permit adequate compaction.

4. Brush and slash are placed in relatively thin lifts between layers of compacted embankment soil.

Experience with the Route 73 project thus far has demonstrated that it is possible to construct satisfactory embankments utilizing landfill waste. The decision to do so must necessarily depend upon an evaluation of engineering feasibility and aesthetics. More specifically, these would include:

1. Availability of disposal sites.
2. Volume of landfill wastes.
3. Waste composition.
4. State of waste decomposition.
5. Possible deleterious effect of the use of landfill waste on water quality.
6. Nature of embankment soil.
7. Time constraints (effect of waiting periods).

A primary concern is the heterogeneous nature of the material. Relative compaction obviously cannot be used as a control test. Thus, the engineer must exercise a high degree of judgment and supervision over the operation and be prepared to make modifications as the character of the waste changes. Shear strength and consolidation characteristics, if necessary, must be determined by in-situ testing. Instrumentation is of fundamental importance in controlling or modifying the operation.

Laboratory studies and dynamic response analysis have indicated that the systematic inclusion of certain nonbiodegradable wastes (tire sidewalls) could possibly beneficiate the fill permitting steeper side slopes and increasing resistance to earthquake loading.

A test embankment to evaluate this premise is now planned for construction on Route 4 (Contra Costa County) within the next year. It will be constructed at varying side slopes reinforced with tire sidewall mats at 0.5 meter (1-1/2 foot) intervals. The performance of the completed embankment will be monitored by instrumentation installed during its construction. The test embankment will ultimately be incorporated into an extension of existing Route 4 several years hence.

ACKNOWLEDGMENTS

Appreciation is expressed to Districts 04, 05 and 07 for the cooperation and assistance extended to various portions of this study.

In particular, appreciation is extended to Messrs. Bill Russel, and B. C. Bachtold for their work on the Nonbiodegradable project in District 04; Roland Brown, Resident Engineer on the District 05 project where the use of wood waste was evaluated; and H. J. Amos; R. D. Siefried and Don Durinski on the District 07 project involving Sanitary Landfill Waste.

At the Transportation Laboratory Messrs. Rogel Prysock, Mas Hatano, and Ray Leech each contributed time and special skills to different phases of the project.

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USE OF WASTE MATERIALS IN EMBANKMENT CONSTRUCTION

LIST OF ILLUSTRATIONS AND PHOTOGRAPHS

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Figure 7: Unsuitable material stockpiled for disposal.

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Figure 10: Closeup view of blended layers.

Figure 11: Finite Element Mesh, shear strain.

Figure 12: Finite Element Mesh, shear stress.

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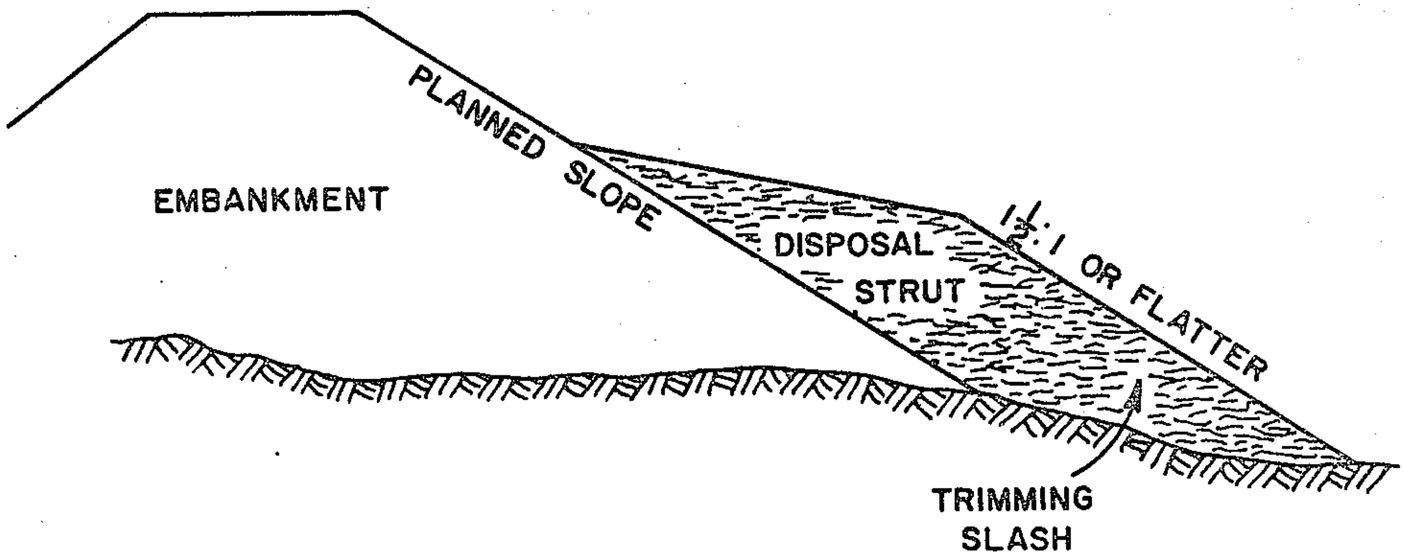
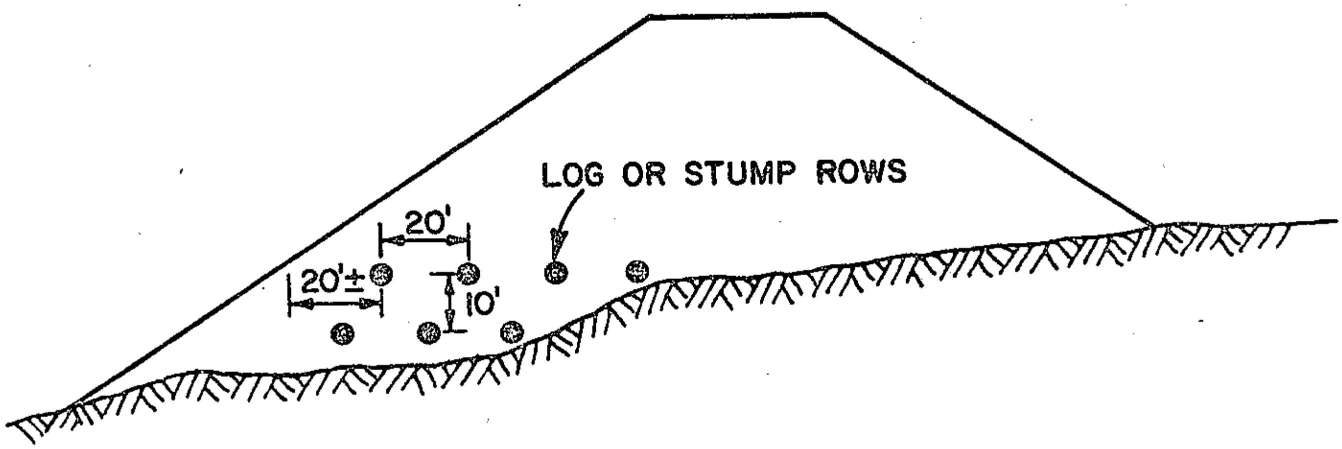
Figure 15: Typical section of proposed instrumentation of a control section of Road 04-CC-4, P.M. 4.4/4.5.



TYPICAL DISPOSAL STRUT



LOG & STUMP DISPOSAL

Figure 1

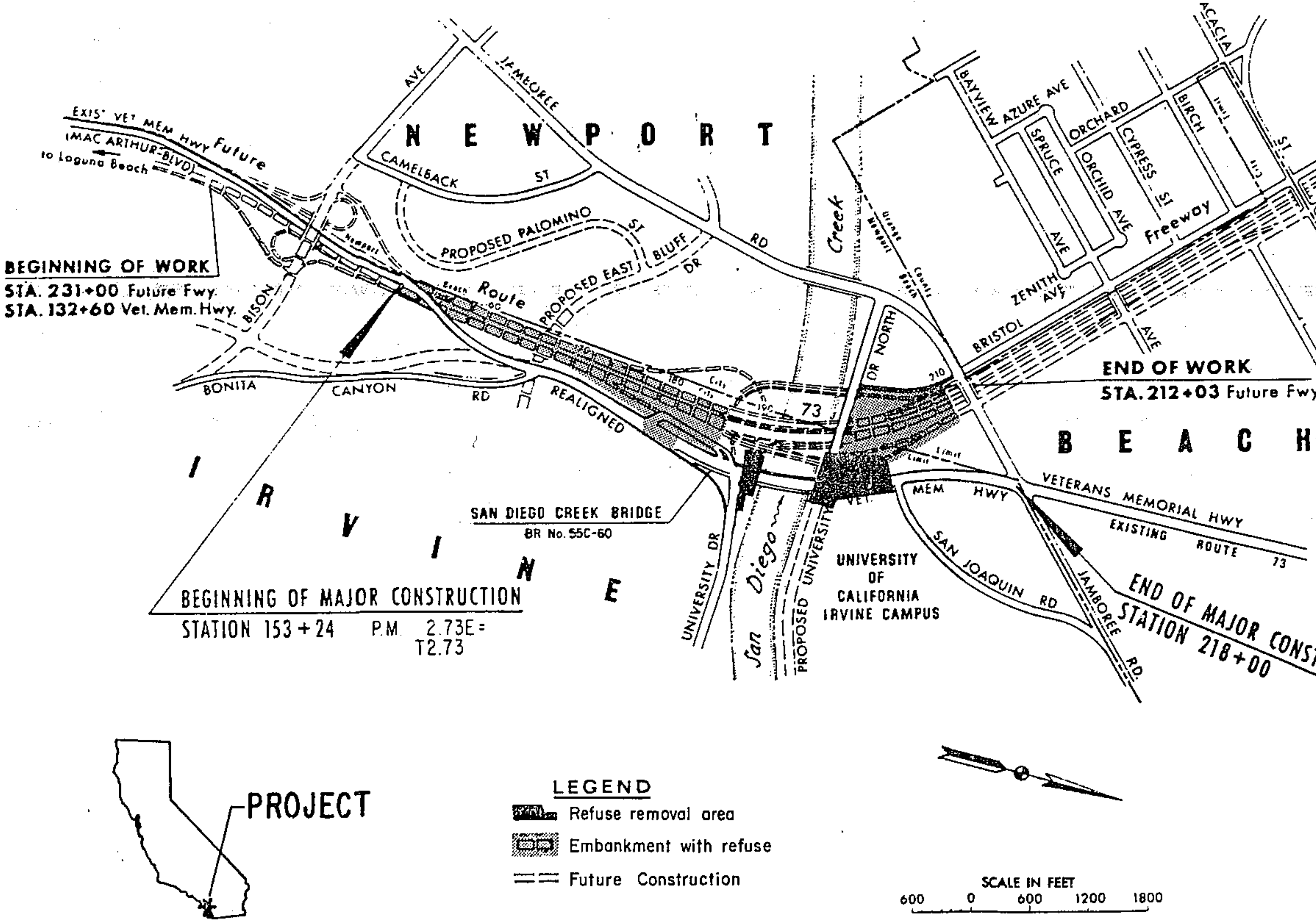
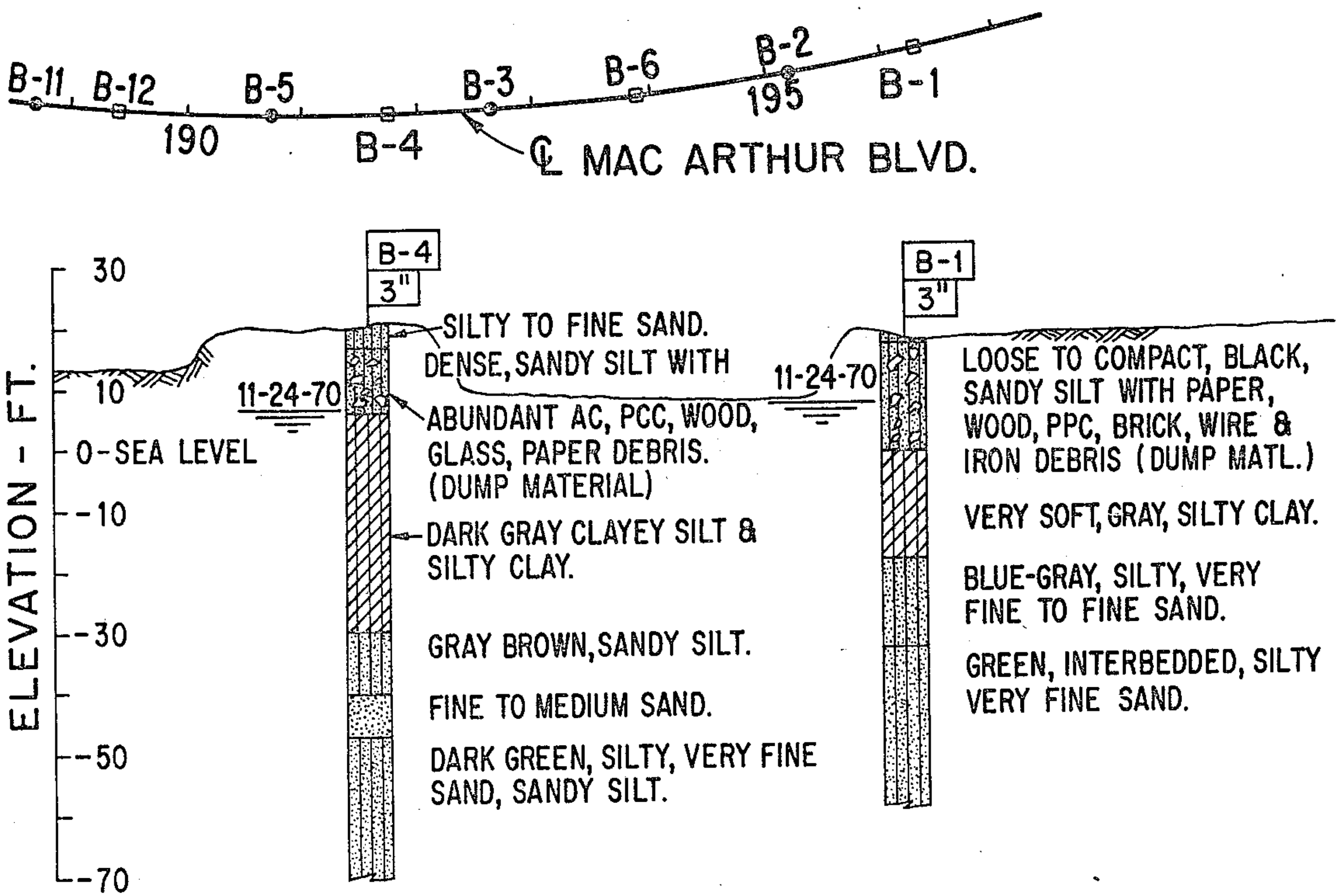


Figure 2 LOCATION MAP



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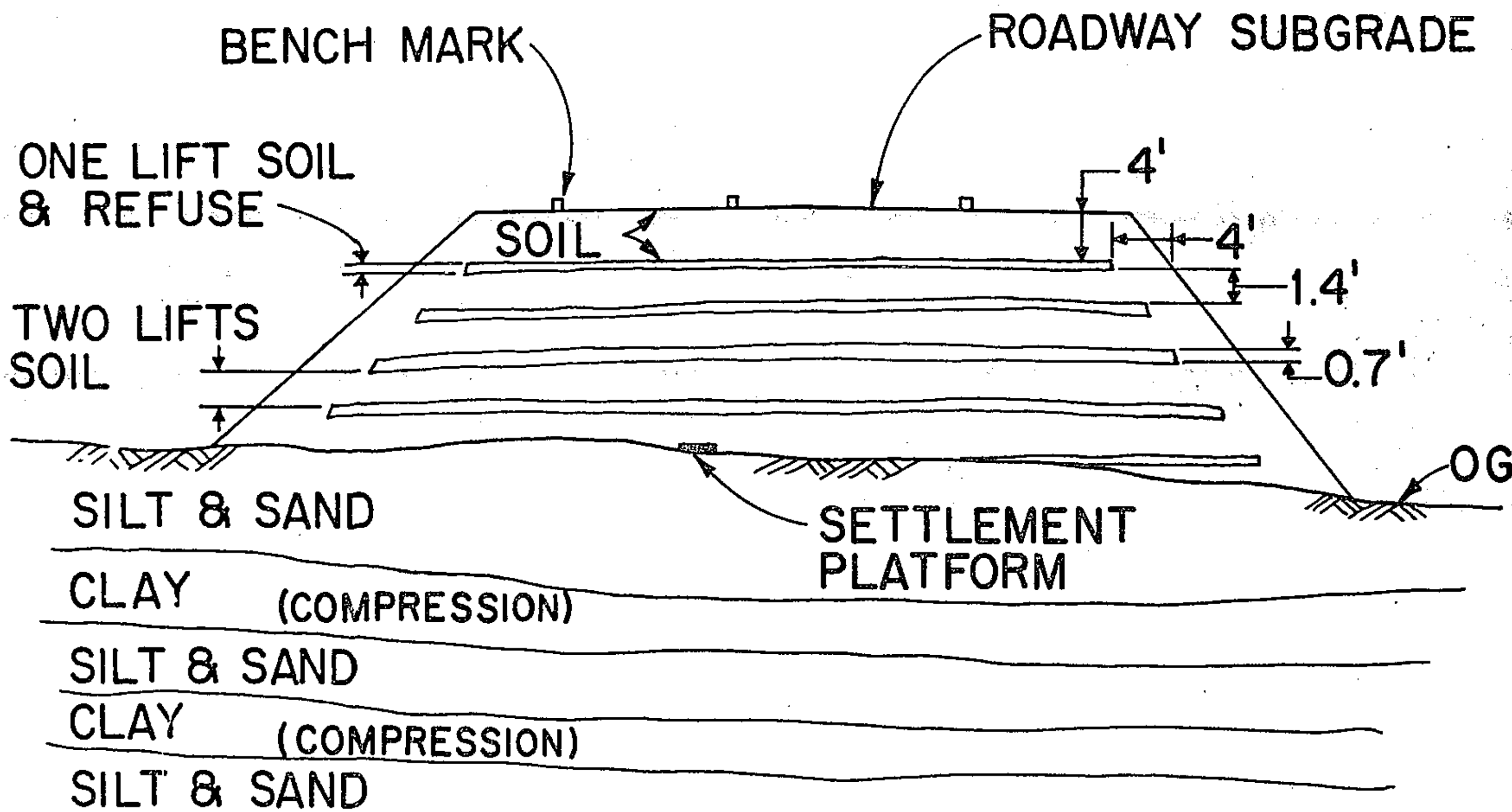
B-2
B-1
190
B-4
195
℄ MAC ARTHUR BLVD.
ELEVATION - FT.
30
10
0-SEA LEVEL
-10
-30
-50
-70
B-4
3"
11-24-70
SILTY TO FINE SAND.
DENSE, SANDY SILT WITH
ABUNDANT AC, PCC, WOOD, GLASS, PAPER DEBRIS. (DUMP MATERIAL)
DARK GRAY CLAYEY SILT & SILTY CLAY.
GRAY BROWN, SANDY SILT.
FINE TO MEDIUM SAND.
DARK GREEN, SILTY, VERY FINE SAND, SANDY SILT.
B-1
3"
11-24-70
LOOSE TO COMPACT, BLACK, SANDY SILT WITH PAPER, WOOD, PPC, BRICK, WIRE & IRON DEBRIS (DUMP MATL.)
VERY SOFT, GRAY, SILTY CLAY.
BLUE-GRAY, SILTY, VERY FINE TO FINE SAND.
GREEN, INTERBEDDED, SILTY VERY FINE SAND.

Figure 3



TYPICAL CROSS SECTION
OF ENGINEERED REFUSE FILL
AND SUBSTRATA
(NO SCALE)

Figure 4

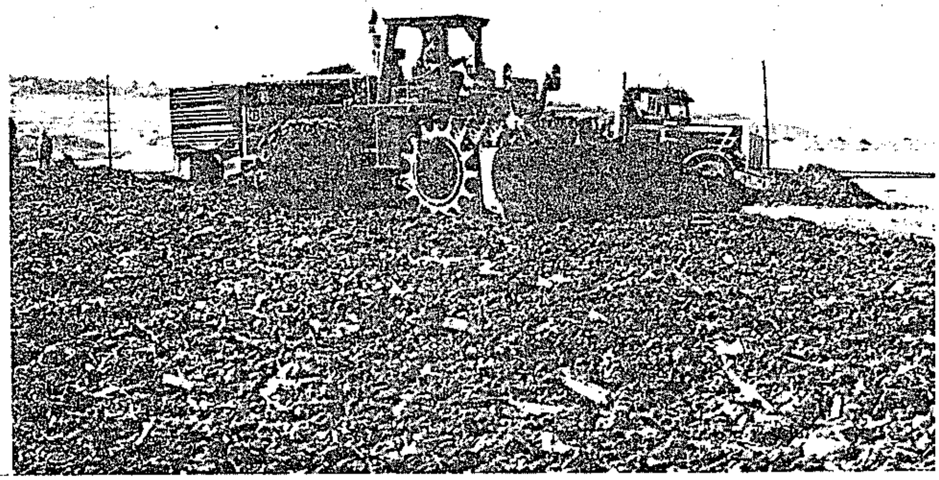


Figure 5 Sheepsfoot compactor processing refuse soil layer.

Figure 6 Refuse in place ready for mixing with soil.

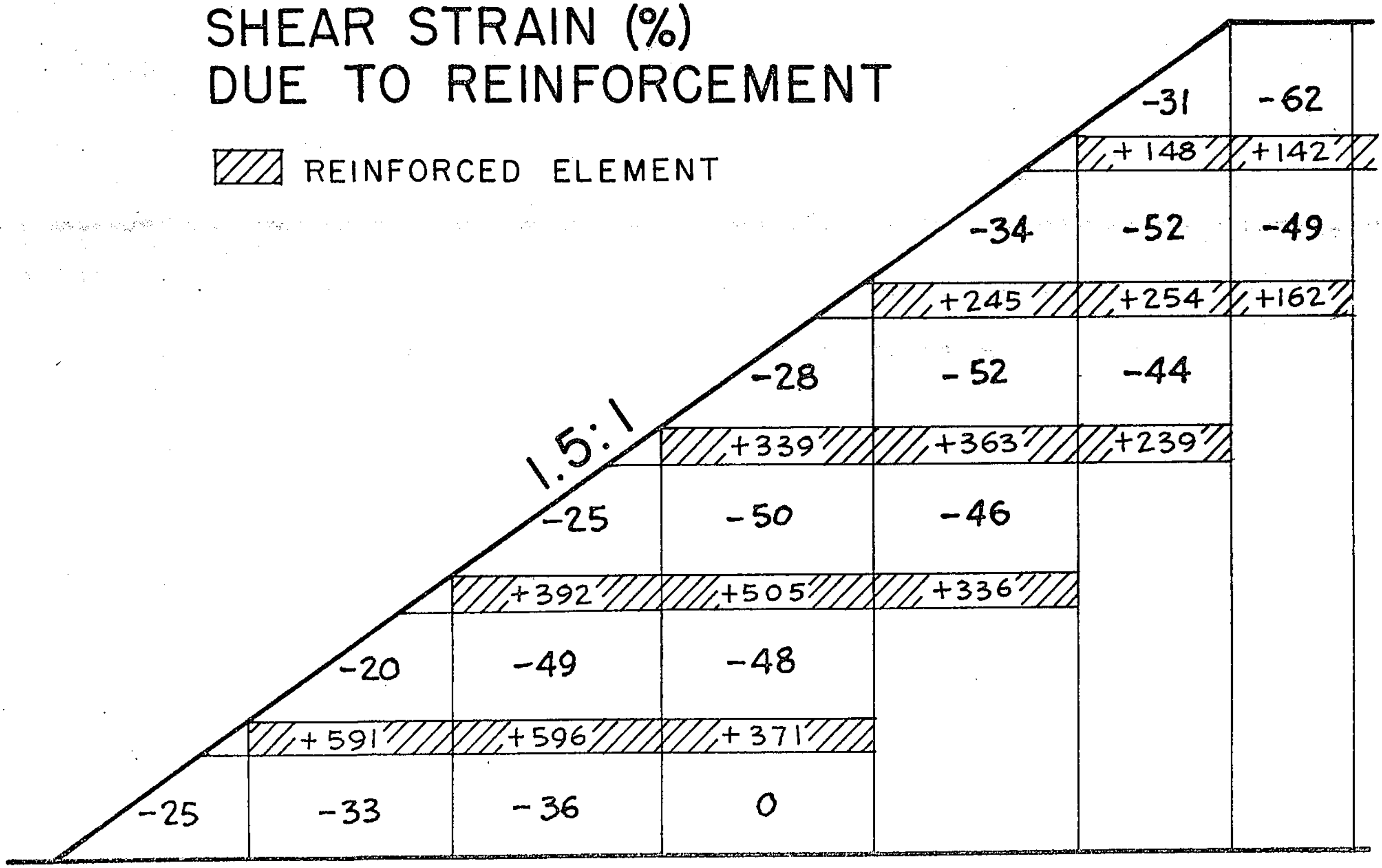
Figure 7 Refuse rejected as unsuitable.

Figure 8 Bottom dump delivers load as rubber-tired dozer spreads soil over refuse.

Figure 9 Blended refuse layer (Center of Photo) exposed by 5-foot deep trench excavation.

Figure 10 Closeup view of blended refuse seen in Figure 9.

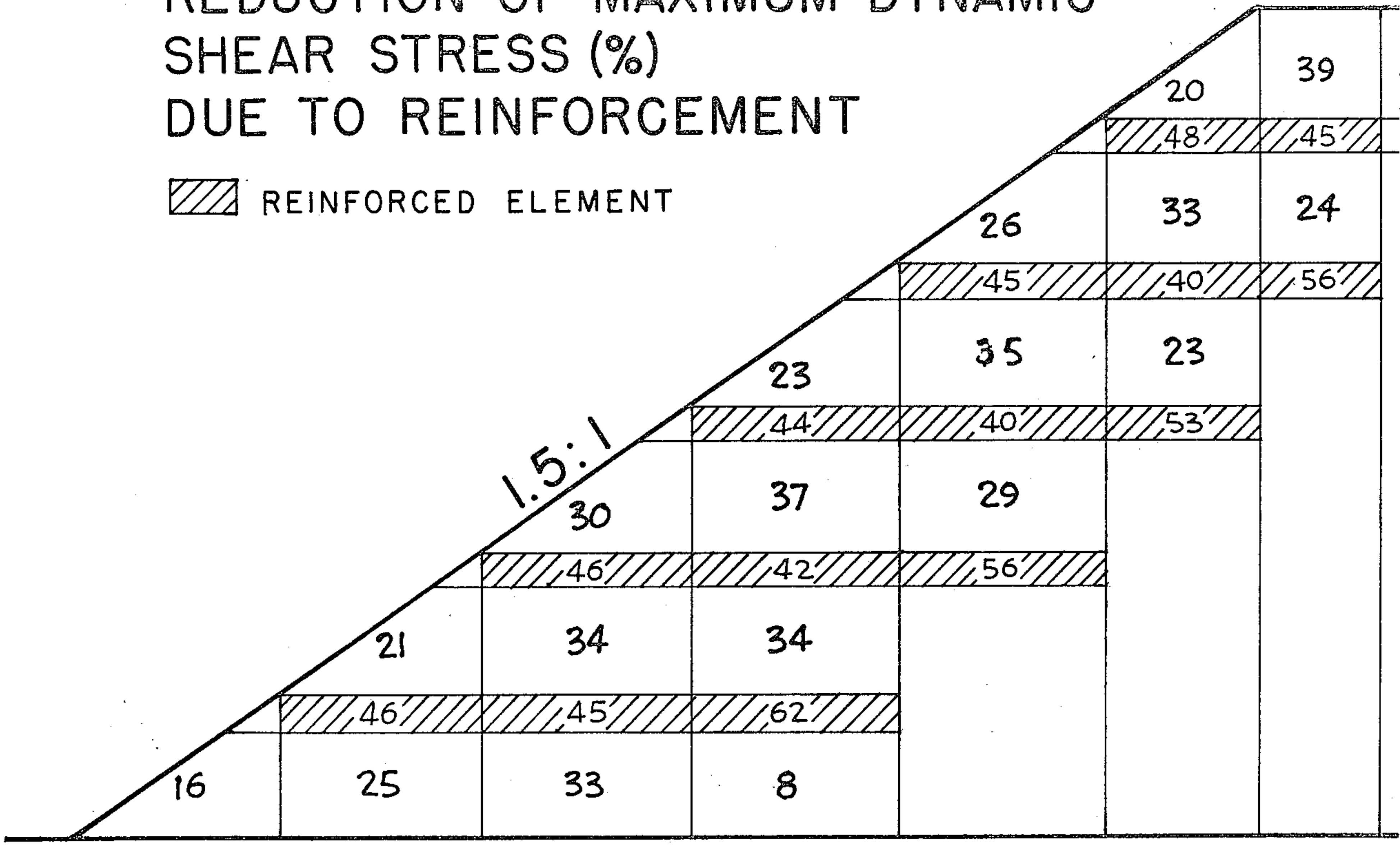
CHANGE IN MAXIMUM DYNAMIC SHEAR STRAIN (%) DUE TO REINFORCEMENT



Scale 1"=4'

Fig 11

REDUCTION OF MAXIMUM DYNAMIC SHEAR STRESS (%) DUE TO REINFORCEMENT



Scale 1" = 4'
Fig 12

DISCARDED AUTOMOBILE TIRES USED
FOR EMBANKMENT REINFORCEMENT

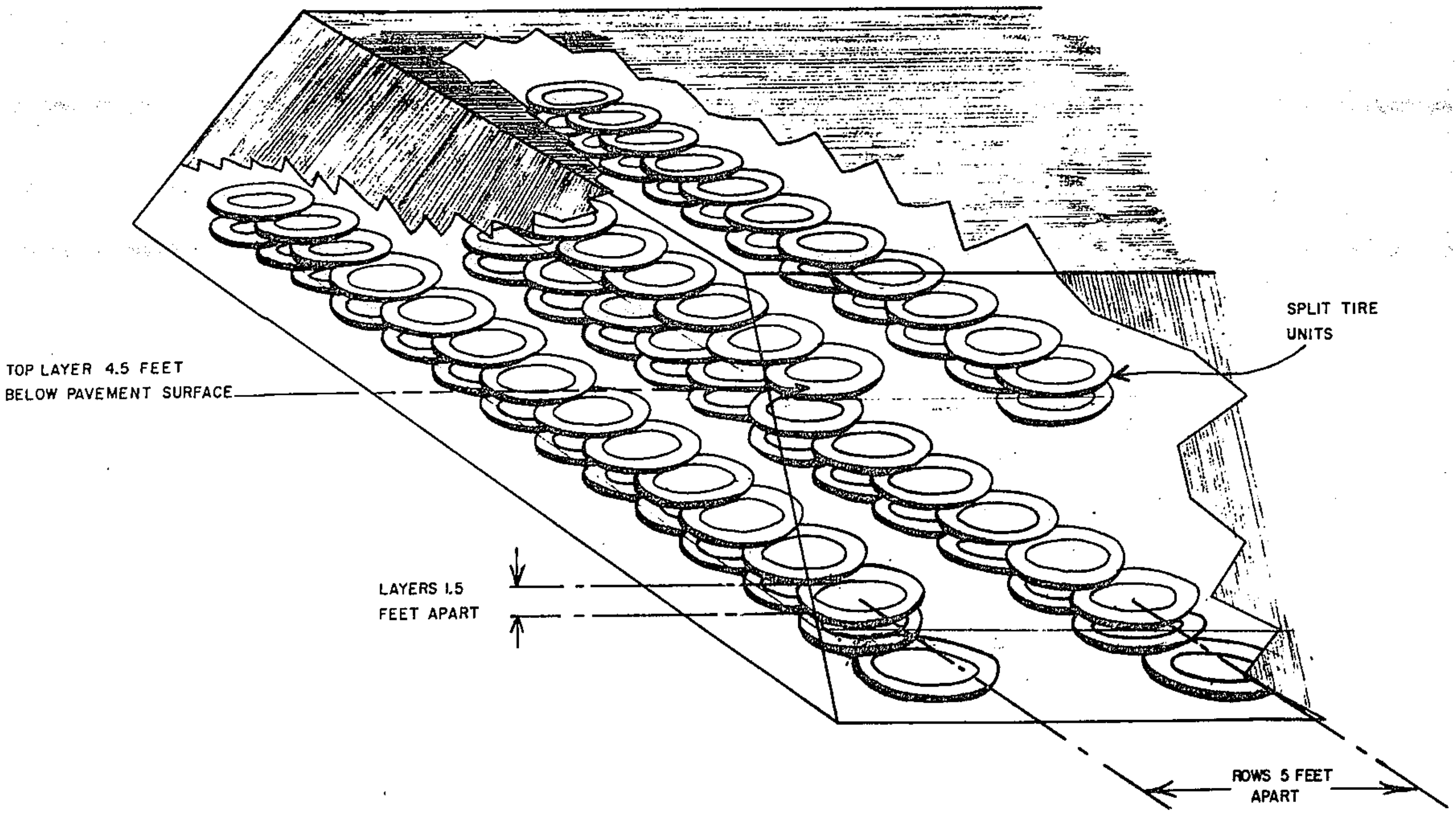
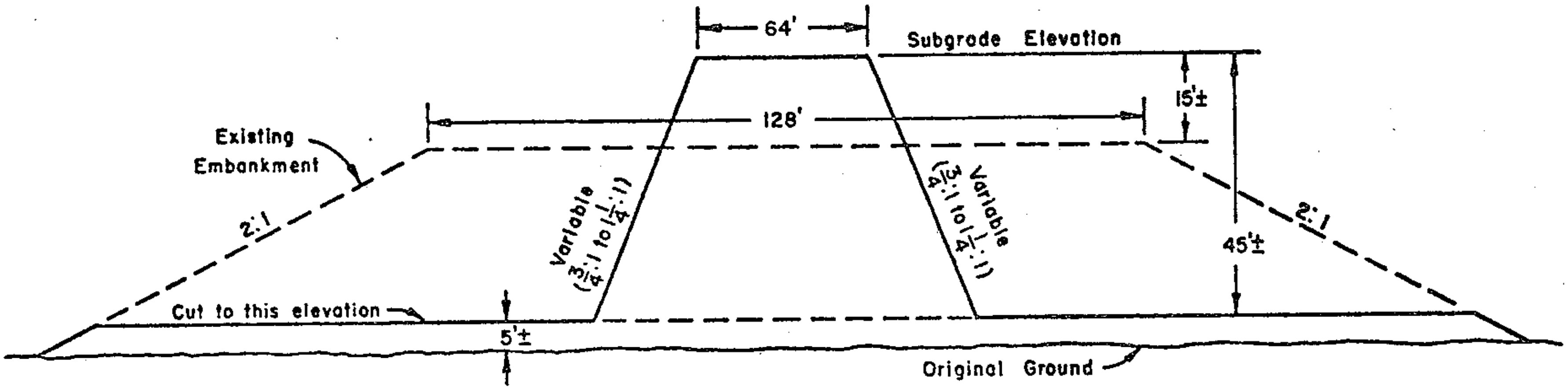


Figure 13 SCHEMATIC OF PROPOSED AUTO-TIRE PLACEMENT



Scale: 1" = 30'

TYPICAL SECTION

PROJECT 04-CC-4 PM 4.4/4.5

PROPOSED EMBANKMENT CONSTRUCTION

Figure 14

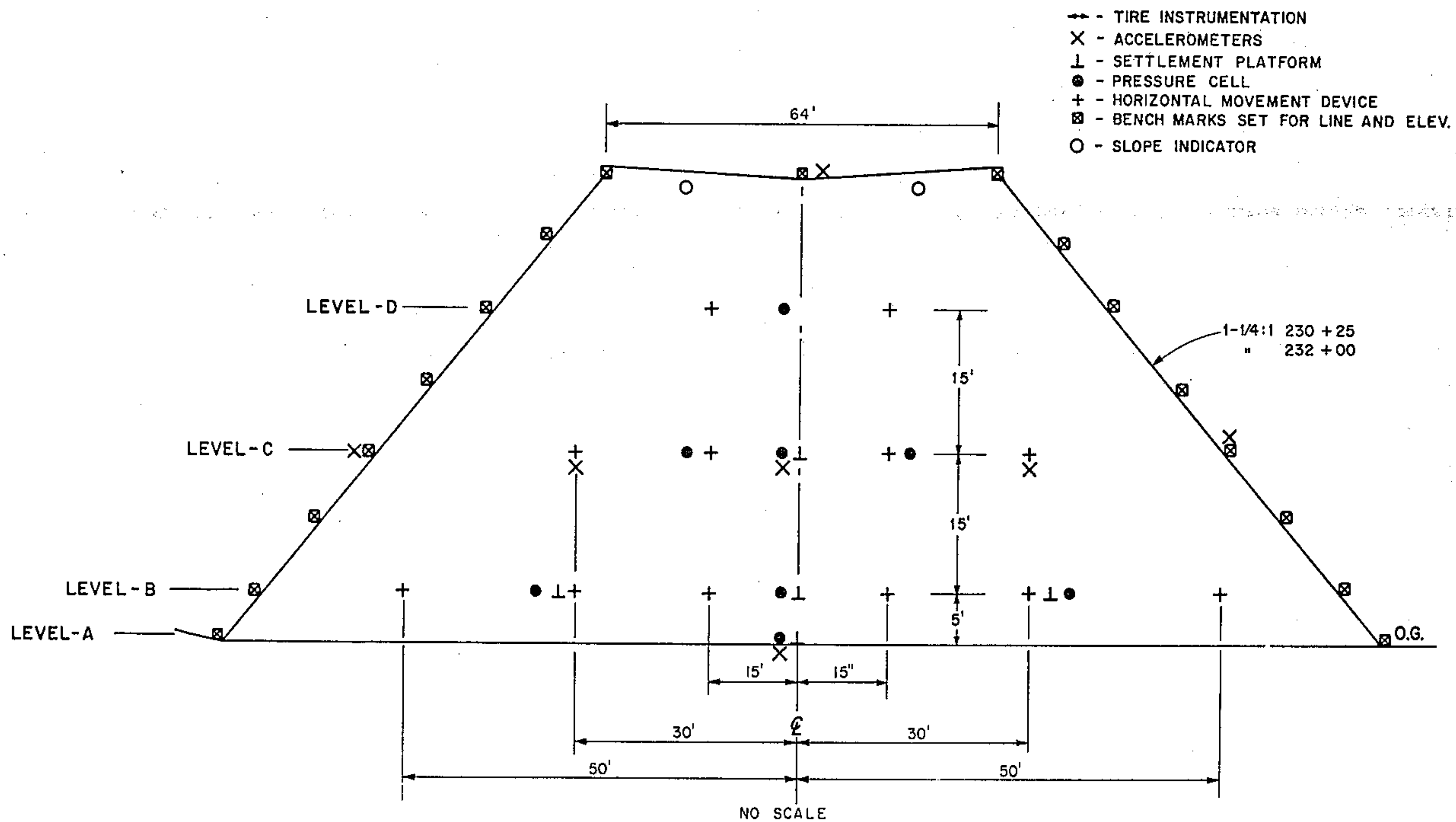


Figure 15 PROPOSED INSTRUMENTATION CONTROL SECTION